Research Article

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Productivity and economic benefits of coconut based vegetable cropping systems under central dry zone of Karnataka

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Abstract

Coconut based cropping systems with vegetables *i.e.,* okra-fallow (2012-13) and tomato-fallow (2013-14), green manure-cucumber, baby corn-gherkin and coconut monocropping as control with four integrated nutrient management (INM) practices *viz*., inorganic fertilizer alone (100%), 5 ton farm yard mannure (FYM)+75% NPK+25% N by vermicompost (VC), 5 ton FYM+50% NPK+25% N by vermicompost+25% N by composted coir pith (CCP)+ Indian Institute of Horticulture Research (IIHR) micronutrient spray and 5 ton FYM+50% N by vermicompost+50% N by CCP+vermiwash spray+Azatobacter were evaluated at HRS, Arsikere, Karnataka during the year 2012 to 2014 by adopting factorial RBD with five replications. All the vegetable crops gave the highest yield under integration of organic and inorganic manure treatments, *viz.,* 5 tonne FYM+74% NPK +25% N by VC and 5 ton FYM+50% NPK+25% N by vermicompost+25% N by CCP+IIHR micronutrient spray, whereas the lowest vegetables yield was noticed with 5 ton FYM+50% N by vermicompost+50% N by CCP + vermiwash spray + Azatobacter. Cropping sequence, baby corn-gherkin resulted in the highest coconut equivalent yield of intercrops and cropping system (33,548 nuts ha^{-1} and 44,414 nuts ha^{-1}, respectively). Pooled economic analysis indicated that, okra-fallow and tomato-fallow sequence resulted in significantly higher net income (₹ 4,03,551 ha^{-1}) compared to other sequences and it was on par with baby corn-gherkin sequence (₹ 3,60,365 ha^{-1}).

Keywords: Coconut, INM, intercropping, vegetables

Introduction

About 80 per cent of coconut in the world is cultivated by small farmers, and these small holdings are mainly committed to coconut monocrop, which normally occupy the land for about a century. Under such monocropping system, majority of the coconut holdings do not generate adequate income and employment for the dependent families. From the land utilization point of view, a pure stand of coconut utilizes 22 per cent of the area at a spacing of 7.5 x 7.5 m, and the remaining area can be utilized for growing variety of useful seasonal crops. The rooting pattern of coconut indicates that over 95 per cent of the roots are found in the top 0-120 cm, of which 19 and 63 per cent of roots are confined to top 0-30 cm and 30-90 cm depth, respectively (Maheswarappa *et al.,* 2000) which suggests feasibility of growing intercrops. Cropping systems aim at crop diversification and intensive cropping in interspace available in the coconut and utilization of available natural resources like soil, water, light and other inputs such as fertilizers, labour *etc*, are efficiently utilized to produce nuts, edible and non-edible products in a profitable way. Several reports indicate the beneficial effects of such cropping systems (Bavappa and Jacob, 1982; Bavappa *et al*., 1986; Maheswarappa *et al*., 2003). Information on influence of vegetable cropping sequences with integrated nutrient management on yield and

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profitability in coconut based system is meagre, hence, an experiment was undertaken to evaluate the vegetable based cropping systems in coconut garden.

Materials and methods

The experiment was undertaken at the Horticulture Research Station Arasikere, Karnataka, during the period 2012-14. The station received an average annual rainfall of 302.6 mm during 2012-13 and 518.7 mm during 2013-14. The mean maximum air temperature was higher in the month of April (34.1 °C) and May (38 °C) during 2012. The mean minimum temperature was less than normal during all the months of 2012 and 2013. The experiment consisting of cropping sequence and nutrient management was laid out in a Factorial Randomized Complete Block Design (FRBD) with five replications.

The seeds/seedlings of okra, baby corn, cucumber and gherkin were sown and tomato seedlings were planted as intercrop in coconut (Tiptur tall) garden aged 45 years, spaced at 10 m x 10 m. For growing intercrops, plots were prepared by leaving 2 m radius from the bole of the coconut and accordingly 60 per cent of the land was utilized

Treatments details:

Factor 1: Cropping sequence

	Kharif (2012)	Summer (2013)	Kharif (2013)	Summer (2014)
M_1	Okra (Arka Abay)	Fallow	Tomato (Arka Rakshak)	Fallow
M_2	Green manure (Mucuna)	Cucumber (Shivneri)	Green manure (Mucuna)	Cucumber (Shivneri)
M_3	Baby corn (Syngenta G-5406)	Gherkin (Ajax)	Baby corn (Syngenta G-5406)	Gherkin (Ajax)
M_4	Coconut monocropping (Control)			

Factor 2: Nutrient management practices

S_1: Inorganic fertilizer alone (100%)

S_2: 5 t FYM + 75% NPK + 25% N by Vermicompost

S_3: 5 t FYM + 50% NPK + 25% N by Vermicompost + 25% N by composted coir pith (CCP) + IIHR micronutrient spray

S_4: 5 t FYM + 50% N by Vermicompost + 50% N by CCP + Vermiwash spray + Azatobactar

Fertilizers and micronutrient dose

Sl. No.	Common name	Recommended dose of fertilizer (NPK kg ha^{-1})	IIHR vegetable special dosage (g L^{-1} of water)
1	Okra	125:75:63	2
2	Tomato	250:250:250	5
3	Baby corn	100:60:75	2
4	Cucumber	60:50:80	1
5	Gherkin	260:175:260	1

(Source: POP, UAS, Bangalore)

Plot Size

Gross plot : 6 m x 5 m

Net plot area

Okra : 4.8 x 4.2 m

Tomato : 4.5 x 4.2 m

Baby corn : 4.0 x 4.8 m

Cucumber : 4.0 x 4.05 m

Gherkin : 4.0 x 4.05 m

to grow intercrops. Uniform quantity of farm yard manure was applied to each plot except S_1 at the rate of 5 tons per hectare. Different organic manures like vermicompost (VC) and composted coir pith (CCP) were applied to plots as per treatments. The organic manures were applied two weeks before sowing/transplanting of vegetable crops and mixed well with the soil. The recommended dose of fertilizers were applied in the form of urea, single super phosphate and muriate of potash as per the treatments. 50 per cent of the N fertilizer was applied before planting and 50 per cent as top dress at 30 days after sowing (DAS). Recommended dose of IIHR vegetable special was sprayed at 30 and 60 DAS. Vermiwash was sprayed by diluting 1:10 ratio with water at 30 and 60 DAS. Azatobactar was applied at the rate of 2 kg ha^{-1} after thoroughly mixing with FYM *i.e.*, 5 t ha^{-1}. Irrigation was provided during summer with drip irrigation system based on pan evaporation data of the region.

The gross returns from the economic produce of coconut and vegetable crops were worked out by considering the market price prevailed during 2012-2014. The cost of production was calculated considering labour charges, cost of manures, fertilizers, seeds and other inputs used for raising the crops. The net return was computed as the difference between the gross returns and the cost of production. The coconut equivalent yield (CEY) of intercrops, system productivity as well as economics was worked out for different crops based on prevailing market price of input and output. The data were subjected to statistical analysis as per the procedure given by Gomez and Gomez (1984).

Results and discussion

Yield of vegetable crops

Yield obtained from different vegetable crops (Table 1) indicated that during the study period, okra (9.9 t ha^{-1}), baby corn (4.8 t ha^{-1} and 4.4 t ha^{-1}), gherkin (74.0 t ha^{-1} and 75.7 t ha^{-1}) and cucumber (6.6 t ha^{-1} and 6.5 t ha^{-1}) vegetables gave significantly higher yield under integration of organic and inorganic manure treatment, *viz.,* S_3. In okra integrated nutrient management practices had a significant impact on the yield and S_3 treatment recorded significantly the highest yield per hectare as intercrop (9.9 t ha^{-1}) and it was on par with S_1 treatment (8.8 t ha^{-1}). The lowest yield was recorded in S4 treatment (7.4 t ha^{-1}). In case of tomato, yields under different nutrient management practices did not differ significantly. The availability of nutrients through the application of organic sources or inorganic sources of nutrients resulted in higher yield of tomato. Bahadur *et al.* (2004) also reported that application of organic manures combined with recommended dose of inorganic fertilizers showed superior performance in yield attributing characters in tomato.

In baby corn, during both the years, significantly higher yield per hectare was obtained as intercrop (4.8 and 4.4 t ha^{-1}) under S_3 treatment and the lowest yield per hectare (3.4 and 3.7 t ha^{-1}) was recorded under S_4 treatment. Significantly higher yield per hectare as intercrop was under S_3 treatment (4.6 t) and the lowest was under S_4 treatment (3.5 t) when pooled analysis of both the years was done. Application of different organic manures + 1/3rd NPK recorded significantly higher cob yield in baby corn when grown as intercrop in

$$\text{Coconut equivalent yield of intercrops (nuts ha}^{-1}\text{)} = \frac{\text{Yield of intercrop (kg ha}^{-1}\text{)} \times \text{Market price of intercrop (₹ kg}^{-1}\text{)}}{\text{Market price of coconut (₹)}}$$

$$\text{Total system productivity (nuts ha}^{-1}\text{)} = \text{Yield of coconut (nuts ha}^{-1}\text{)} + \frac{\text{Yield of intercrop (kg ha}^{-1}\text{)} \times \text{Market of price intercrop (₹ kg}^{-1}\text{)}}{\text{Market price of coconut (₹)}}$$

Table 1. Yield (t ha^{-1}) of vegetable crops as intercrops under coconut as influenced by integrated nutrient management practices

Treatments/ Crops	Okra (Kharif)	Tomato (Kharif)	Baby corn (Kharif)		Gherkin (Summer)		Cucumber (Summer)	
	2012	2013	2012	2013	2013	2014	2013	2014
S_1	8.77 ^{ab}	71.73	3.54 ^{b}	4.07 ^{ab}	64.42 ^{c}	65.74 ^{c}	5.43 ^{bc}	4.90 ^{c}
S_2	7.58 ^{b}	72.95	3.77 ^{b}	3.72 ^{b}	68.54 ^{ab}	72.14 ^{b}	5.64 ^{b}	5.59 ^{b}
S_3	9.85 ^{a}	69.18	4.75 ^{a}	4.36 ^{a}	74.04 ^{a}	75.69 ^{a}	6.55 ^{a}	6.48 ^{a}
S_4	7.35 ^{b}	68.51	3.40 ^{b}	3.68 ^{b}	58.34 ^{b}	64.52 ^{c}	4.67 ^{c}	4.58 ^{c}
CD (P=0.05)	1.58	NS	0.82	0.51	7.45	3.50	0.63	0.63

S_1: Inorganic fertilizer alone 100%
S_2: 5 ton FYM + 75% NPK + 25% N by vermicompost
S_3: 5 ton FYM + 50% NPK + 25% N by vermicompost + 25 % N by CCP + IIHR micronutrient spray
S_4: 5 ton FYM + 50% N by vermicompost + 50 % N by CCP pith + vermiwash spray + Azatobacter

coconut garden and was on par with organic manures alone treatment (Maheswarappa *et al.,* 2013). The beneficial role of integrated nutrient management in improving soil physical, chemical and biological properties which in turn helps in better nutrient absorption by plant and resulting in higher yield has been reported (Prabhu *et al.,* 2002). It was also reported that, the INM has significant effect on growth parameters of maize crop in a field trial conducted at ICAR Research Complex at Umiam, Meghalaya (Panwar, 2008). Integrated nutrient management had positive effect on growth parameters of maize such as leaf area and plant height (Kannan *et al*., 2013).

In gerkhin, during 2013 and 2014, fruit yield per hectare as intercrop (74.0 t ha^{-1} and 75.7 t ha^{-1}, respectively) was significantly higher under S_3 treatment and was on par with S_2 during 2014 and the lowest yield (58.3 t ha^{-1} and 64.5 t ha^{-1}, respectively) was recorded under S_4 treatment. In the pooled analysis also, S_3 recorded significantly higher yield (74.9 t ha^{-1}). The results are in agreement with the findings of Kumaran *et al*. (1995), who recorded an increase in fruit yield by the application of NPK with FYM and vermicompost.

In cucumber, during 2013 and 2014, significantly higher yield per hectare was observed as intercrop under S_3 treatment (6.6 and 6.5 t ha^{-1}, respectively) and the lowest yield per hectare (4.7 and 6.5 t ha^{-1}, respectively) was recorded in S_4 treatment. Higher yield of cucumber in present study could be due to the influence of combination of organic and inorganic sources of nutrients which enhanced the synthesis of photosynthates by increasing the synthesis of growth regulators like IAA, GA, amino acids, and vitamins. The number of fruits per vine, fruit length and fruit yield were significantly higher in cucumber with the combined application of organic manures + biofertilizers + 50 per cent of RDF compared to RDF (Narayanamma *et al.,* 2010).

Use of both organic and inorganic nutrient sources together confirms the significance of conjunctive use of chemical and organic fertilizers than the individual one which might be due to the solubilization effect of plant nutrients by the addition of FYM and vermicompost leading to increased uptake of NPK (Subbiah *et al*., 1982). Besides supplying plant nutrients, vermicompost contains plant growth regulators and humic acid which probably have additive effect on plant growth (Tomati *et al.,* 1988).

Yield of coconut

A gradual increase in nut yield per palm was observed over the years under vegetable intercropped area. After two years of experiment, palm under intercropping area registered an increase in nut yield of 22 per cent (from initial 64 to 78 nuts per palm), whereas in monocropping area increase in nut yield was only 4.68 per cent (from initial 64 to 67 nuts per palm).

Coconut equivalent yield of intercrops and total system productivity

Coconut equivalent yield (CEY) of the intercrops and system productivity of coconut based

cropping system were worked out and is presented in Table 2. Pooled analysis of coconut equivalent yield of intercrops showed that there was significant difference among the cropping sequences. Cropping sequence, M_3 (baby corn-gherkin) resulted in the highest coconut equivalent yield of 33,548 nuts ha^{-1} followed by M_1 sequence (okra-fallow-tomato-fallow) of 29,960 nuts ha^{-1}, while M_2 (green manure-gherkin) recorded the lowest coconut yield of 22,459 nuts ha^{-1}. However, INM practices and the interaction of sequences of INM practices had no significant impact on coconut equivalent yield of intercrops. The coconut equivalent yield of cropping systems also showed the similar results. In the pooled analysis of both the years, M_3 (baby corn-gherkin) gave significantly the highest CEY of

Table 2. Effect of cropping sequence and integrated nutrient management practices on coconut equivalent yield of intercrops and cropping systems

Treatments	Coconut equivalent yield of intercrops			Coconut equivalent yield of cropping systems		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
M_1	18640	41281	29960	28240	53414	40827
M_2	15653	29265	22459	25253	41399	33326
M_3	41797	25299	33548	51397	37432	44414
M_4	-	-	-	6300	6400	6350
S.Em±	1168.8	879.12	825.30	1186.9	892.8	838.1
CD (P=0.05)	3363.0	2529.45	2374.6	3419.2	2571.7	2414.3
S_1	25363	33190	29276	34963	45323	40143
S_2	24392	33894	29143	33992	46027	40009
S_3	28468	31252	29860	38068	43385	40726
S_4	23230	29458	26344	32830	41592	37211
S.Em±	1349.6	1015.13	952.97	1370.6	1030.9	967.7
CD (P=0.05)	NS	NS	NS	NS	NS	NS
M_1S_1	14613	33476	24044	21813	42576	32194
M_1S_2	12638	34976	23807	19838	44076	31957
M_1S_3	16418	29019	22718	23618	38119	30868
M_1S_4	12253	26372	19312	19453	35472	27462
M_2S_1	12159	21715	16937	19359	30815	25087
M_2S_2	10324	21780	16052	17524	30880	24202
M_2S_3	12467	21593	17030	19667	30693	25180
M_2S_4	12009	22709	17359	19209	31809	25509
M_3S_1	30296	19486	24891	37496	28586	33041
M_3S_2	31920	19505	25713	39120	28605	33863
M_3S_3	35168	19704	27436	42368	28804	35586
M_3S_4	28007	17201	22604	35207	26301	30754
S.Em±	2337.6	1758.3	1650.6	2373.9	1785.5	1676.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS

NS: Non Significant
M1: Okra-fallow, Tomato-fallow
M2: Green manure (Maccuna)-Cucumber
M3: Babycorn- Gherkin
M4: Coconut monocropping (Control)

cropping system of 44,414 nuts ha^{-1} followed by M_1 sequence (okra-fallow-tomato-fallow) *i.e.,* 40827 nuts ha^{-1}. Significantly the lowest CEY of cropping system was recorded in M_2 (green manure-gherkin) sequence with 33326 nuts ha^{-1}. Higher coconut equivalent yield in above intercropping systems can be attributed to relatively better performance of vegetable crops and also better market prices for their produce. Similar increase in coconut equivalent yield in coconut based cropping system was reported by Basavaraju *et al.* (2008) and Kishnakumar *et al.* (2011). Interaction effect of integrated nutrient management practices and cropping sequences did not show any significant difference in the coconut equivalent yield.

Table 3. Effect of cropping sequence and integrated nutrient management practices on economics of coconut based cropping system

Treatments	Total cost (₹ ha^{-1})		Gross income (₹ ha^{-1})			Net income (₹ ha^{-1})		
	2012 - 13	2013 - 14	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
M_1	220634	197078	423600	801213	612406	202966	604135	403551
M_2	214062	200866	378795	620982	499888	164733	420116	292425
M_3	297704	314001	770956	561479	666217	473252	247478	360365
S.Em±	-	-	17804	13391	12571	27344	13391	15744
CD (P=0.05)	-	-	51288	38576	36214	78770	38576	45354
S_1	192393	189974	524450	679843	602147	332057	489869	410963
S_2	222247	224673	509876	690405	600141	287629	465732	376681
S_3	254089	235903	571018	650774	610896	316929	414871	365900
S_4	280530	353254	492457	623876	558166	211927	270622	241275
S.Em±	-	-	20558	15463	14516	31575	15463	18180
CD (P=0.05)	-	-	NS	NS	NS	NS	NS	52370
M_1S_1	129462	147878	327188	638640	482914	197726	490762	344244
M_1S_2	137237	167797	297563	661133	479348	160326	493336	326831
M_1S_3	156827	174366	354263	571789	463026	197436	397423	297429
M_1S_4	167709	242524	291788	532076	411932	124079	289552	206815
M_2S_1	142564	135833	290391	462225	376308	147827	326392	237109
M_2S_2	131903	157702	262853	463200	363027	130950	305498	218224
M_2S_3	140814	163520	295001	460392	377696	154187	296872	225529
M_2S_4	187315	224718	288139	477129	382634	100824	252411	176617
M_3S_1	160858	143732	562434	428783	495608	401576	285051	343313
M_3S_2	230917	180014	586806	429079	507942	355889	249065	302477
M_3S_3	274059	192895	635526	432060	533793	361467	239165	300316
M_3S_4	276169	327579	528102	394515	461309	251933	66936	159434
S.Em±	-	-	35608	26783	25143	54689	26783	31489
CD (P=0.05)	-	-	NS	NS	NS	NS	NS	NS
Control (M_4)	44478	44478	94500	96000	95250	50022	51522	50772
S.Em±			41754	31405	29483	64128	31405	36924
CD (P=0.05)			83999	63180	59311	129009	63180	74281

NS: Non Significant

Economics of the coconut based cropping system

The total cost of production was higher in M_3 sequence compared to other sequences. Under INM practices, it was at higher side in S_4 treatment followed by S_3, S_2 and S_1 as the cost of organic manures were high compared to inorganic fertilizers. Maheswarappa *et al.* (2013) also reported higher total cost of production under organic treatment alone in coconut based high density multi species cropping system. Net income was significantly the highest under M_3 sequence (₹ 4,73,252 ha^{-1}) during 2012-13 and M_1 sequence (₹ 6,041,35 ha^{-1}) during 2013-14. Pooled analysis indicated that, M_1 sequence resulted in significantly higher net income (₹ 4,03,551 ha^{-1}) compared to other sequences but was on par with M_3 sequence (₹ 3,60,365 ha^{-1}). This was mainly attributed to inclusion of tomato crop which had recorded higher yield and there was good price for the produce. These results showed that crop diversification could help the farmers to realize better returns even if the price of one commodity gets reduced in any year. Girijadevi and Muraleedharan Nair (2003) obtained higher net income by intercropping various combinations of component crops such as banana, ginger, turmeric, elephant foot yam and vegetable cowpea in coconut garden. Elephant foot yam and banana were found to ideal as companion crops for coconut (Raveendran, 1997). Under coconut based high density multi species cropping system in root (wilt) affected garden, growing tuber crops like amorphophallus, dioscoria and colocasia resulted in higher net income (Maheswarappa *et al.,* 2003). The economic advantage of high density multi species cropping system in coconut over monocropping was 61 per cent with B:C ratio of 1.59 indicating that coconut based HDMSCS is economically viable in root (wilt) affected areas (Krishnakumar *et al.,* 2011). Among the INM practices, S_1 treatment recorded significantly the highest net income (₹ 4,10,963 ha^{-1}) and was on par with S_2 (₹ 3,76,681/-) and S_3 treatment (₹ 3,65,900/). The net income recorded under S_4 treatment was significantly the lowest (₹ 2,41,275 ha^{-1}). There was no significant difference in net income due to interactions of cropping sequence and INM practices during both the years. Maheswarappa *et al.* (2013) also reported higher net return under integrated nutrient management practices in coconut based HDMSCS.

Conclusion

It is well accepted that intercropping system under coconut is more profitable than monocropping which promises to the farmers with additional productivity of crops, besides generating additional employment opportunity. These results clearly indicated that, vegetable cropping sequences with baby corn-gherkin or okra-fallow/tomato-fallow during kharif and summer months, respectively in coconut garden is the best sequence. However, application of inorganic fertilizers alone gave the highest net return, but considering the soil health, sustainability and proper utilization of organic waste of the coconut garden, integration of both organic and inorganic nutrient sources (5 t FYM + 50% NPK + 25% N by vermicompost + 25% N by composted coir pith (CCP) + IIHR micronutrient spray) found to be productive and profitable for growing intercrops in central dry zone of Karnataka.

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